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Socio-Economic Determinants of Maize Production of Smallholder Farmers in Eastern Oromia, Ethiopia

Murad Mohammed Baker*[1], Desta Bati Nuno[2]
[1]Department of Statistics, College of Computing and Informatics, Haramaya University, Dire Dawa, Ethiopia.
Email: murt.stat@gmail.com
[2]Department of Statistics, College of Computing and Informatics, Haramaya University, Dire Dawa, Ethiopia.
Email: destabati8@gmail.com
**Corresponding author | ORCID: 0000-0002-1226-3145*

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Abstract

Agricultural sector is a mainstay of farmers' livelihoods in Ethiopia. Maize is a largest crop being grown in Ethiopia; however, currently, yield gaps are the challenges faced by the producers. This study has an objective of identifying the determinants of maize production of smallholder farmers. Data were collected from 200 farmers living in the selected kebeles (communes) of Meta district in the East Hararge zone of Oromia region, Ethiopia. The collected data was analyzed using multiple linear regression model. The result showed that the production of maize was influenced by several factors. Non-farm activity had a positive impact on the production of maize. Thus, the farmers who had money from non-farm sources utilized these additional incomes as inputs to gain more maize production. The cultivated areas of land have a positive influence on the higher yields of maize. The maize crop production of smallholder farmers was negatively affected by Development Agent's office. The study suggests that policy makers should encourage the current maize production by supplying improved seeds and fertilizers, which tend to support improving the smallholder farms.

Keywords

Livelihood diversification; Adoption; Crop cultivation; Production factors; Smallholder farmers

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Introduction

In Ethiopia, agriculture is the most important sectors that accounts for 46% of gross domestic product (GDP), 73% of employment and 80% of export values (Bukul, 2018). The agriculture sector is largely dominated by rainfed subsistence farming by the smallholder farmers who cultivate an average landholding of less than a hectare (Amsalu, 2015). Maize is among the major cereal crops produced in the world after wheat and rice (Gebre *et al*, 2019). Maize is also the most widely grown staple food crop in sub-Saharan Africa occupying more than 33 million hectares each year (Macauley and Ramadjita, 2015). It is most dominant cereal crops that the farmers adopt more than the other crops. In sub-Saharan Africa, most of the countries including Ethiopia account about 96% of the total maize production (Macauley and Ramadjita, 2015). The Food and Agricultural Organization (FAO) of the United Nations reported that the maize is commonly important for food security as a basic food for the population in Ethiopia (FAO, 2018). According to the Central Statistical Authority, on an average, the maize product was 2.6 tons per hectare between 2006 and 2017 years (CSA, 2017).

Maize is the largest and most productive crop in Ethiopia. In the year 2007-08, maize production was 4.2 million tons, 40 percent higher than teff[1] (*Eragrostis tef*), 56 percent higher than sorghum and 75 percent higher than wheat production (Rashid, Getnet and Lemma, 2010). Maize is the second most widely cultivated crop in Ethiopia and is grown under diverse agro-ecologies and socioeconomic conditions (Tsedeke *et al.*, 2017). As confirmed by the study done in Ethiopia, most of the farmers (89.5%) apply fertilizer for maize production out of which 75% of them apply inorganic fertilizers, 20.5% apply organic, and 4.5% apply both types of fertilizers (Balemi *et al.*, 2019). The study conducted by Abate *et al*. (2015) showed that the maize area covered by improved varieties in Ethiopia grew from 14% to 40% in 2004-2013, and the application rate of mineral fertilizers grew from 16 to 34 kg/ha during the same period. In Ethiopia, the maize crop production accounts for average 6.7 million tons over 2013-2015 production period (FAO, 2015). Furthermore, as confirmed by a study done in Ethiopia, in comparison to wheat and teff, maize is most important staple food to be consumed and low-priced crop (Abate *et al.*, 2015). The country assessment during 2014-15 about consumption expenditure presented that, among the key cereal crops, maize accounted for 16.7% of domestic calorie consumption compared to sorghum and wheat that accounted for 14.1% and 12.6%, respectively (Berhane *et al*., 2011).

A close look at the country's declining agricultural outputs, and, at the same time, ever-increasing population growth implores for a search of alternatives. One of the alternatives to bridge this ever-increasing gap between the two is the programs that focus mainly on the distribution of physical inputs such as fertilizer, high yielding varieties of seeds, credit supply to smallholders, and training on improved agronomic practices (Gecho and Punjabi, 2011**).** Moreover, it is important to develop the cultivated area for farming maize to ensure the food security and upholding sustainable development of agriculture (Uddin, Hossain and Hasnain, 2020).

Determining the factors affecting the maize production is important to improve the response tools related to the production of maize crop development. Even though some studies are published (Kutoya, Kebede and Yidnekachew, 2019; Yami, Meyer and Hassan, 2020; Gecho and Punjabi, 2011) concentrating on the adoption of technologies and commercial marketing of maize production, there is scarcity of studies that dispensed the determinants of maize production in the study area. Therefore, this study focuses on the influential determinants of maize production among the smallholder farmers in Eastern Ethiopia at large and in the Meta district of the Eastern Hararge zone of Oromia region in particular.

[1] *Eragrostis tef*, also known as teff, Williams lovegrass or annual bunch grass, is an annual grass, a species of lovegrass native to the Horn of Africa, notably to modern-day Ethiopia. It is cultivated for its edible seeds, also known as teff.

Materials and Methods

Description of the study area

The study was conducted in Meta district of East Hararghe zone, Oromia region, Ethiopia. Meta district is one of the 21 districts of Eastern Hararghe zone of Oromia regional in Ethiopia. The district is classified as dearth flat, and various crop failures are a common problem usually leading to food famine. The land use of the Meta district consists of 52% arable land and 21% pasture and forest land, and the rest 27% is considered as degraded land (CSA, 2018). The major food crops in the district are sorghum, maize, barley, wheat, teff, etc. Khat *(Catha edulis)* and coffee are the main cash crops. The farming system of the district consists of crop production (7.9%), livestock production (4.1%), and mixed crop and livestock production (88.0%) (Yuya and Daba, 2018).

Sources of data and methods of data collection

The primary and secondary data were used in this study. Primary data were collected in 2019 using a semi-structured questionnaire that was managed by the trained investigators covering 200 smallholder maize farmers. Secondary data were collected from pertinent published and unpublished documents obtained from the internet, administration bureaus of the district and other available organizations.

Sampling technique and sample size determination

A two-stage sampling technique was employed to select prospective maize producer smallholder farmers. The term 'kebele' referred to a localized group of people under district in Ethiopia. In the first stage, two kebeles that potentially produce maize production were selected from district via purposive sampling methods. During the selection, kebeles that have prospective to the production of maize and accessibility to produce maize were taken into account. In the second stage, the sample size was ascertained proportionally in accordance with the population size of the farmers who produce maize. The population list of maize producer farmers from sample kebeles was consulted. Then, 200 representative farmers were randomly chosen using Yamane (1967) formula, which is as under:

$$n = \frac{N}{1 + N(e)^2} \tag{1}$$

Where *n* is the sample size, *N* is the population size (total household size), and *e is* the level of precision. The population is homogeneous in terms of maize production in the sampled kebeles. Due to the homogeneity of the population, 7% precision level was used for this study to avoid acquiring extra costs and captivating more time for collecting the same set of information on different smallholder maize producer farmers. Based on the number of the total households (9,118) in the sampling frame, the formula calculated and reached a minimum of 200 respondents to be drawn.

Method of data analysis

In order to analyse the data, the descriptive statistics and econometric model were applied. In descriptive statistics, mean, minimum, maximum, percentage and frequency were used to describe the socio-economic data and available opportunities to maize production while multiple linear regression model were applied to identify determinants of maize production among smallholder farmers in the Meta district.

Model specification

Production of maize crops owned by sampled household heads is a continuous dependent variable of the model that was measured in quintal. The appropriate econometric technique to deal with the continuous

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dependent variable is multiple linear regression model and it was the most familiar statistical model used to analyze such data. It is a general statistical technique through which one can analyze the relationship of a continuous response variable and a set of dummy/categorical/continuous explanatory variables (Alexopoulos, 2010). Multiple linear regression model is given as below:

$$\mathrm{MP} = \beta_0 + \beta_1 \mathrm{AGEH} + \beta_2 \mathrm{FSH} + \beta_3 \mathrm{EDLH} + \beta_4 \mathrm{NFI} + \beta_5 \mathrm{CAL} + \beta_6 \mathrm{DTM} + \beta_7 \mathrm{DTDA} + \beta_8 \mathrm{EAM} + \beta_9 \mathrm{AFU} + \beta_{10} \mathrm{AOFU} + \beta_{11} \mathrm{AMI} + \beta_{12} \mathrm{SS}H + \varepsilon$$

Where $\beta_0, \beta_1, \ldots\ldots\ldots\ldots, \beta_{12}$ are the parameters and ε is a random disturbance.

Table 1: Definition and units of measurement of the variables in the multiple linear regression

Variables	Description and measurement
MP	Maize production (quintal)
AGEH	Age of household head (year)
FSH	Family size of household head (number)
EDLH	Educational level of household head (grades or number of years in school)
NFI	Non-farm income of household (dollar)
CAL	Cultivated area of land (hectare)
DTM	Distance to the market (hour)
DTDA	Distance to DA's office (hour)
EAM	Economically active members (number)
AFU	Amounts of fertilizer used (kg)
AOFU	Amounts of organic fertilizer used (kg)
AMI	Access to market information (1= if has a market information, 0 = otherwise)
SSH	Social status of household head in the community (1=if participated, 0 = otherwise)

Assumption of multiple linear regressions

Normality: The residual errors are normally distributed with mean zero and variance σ^2 can be tested by a histogram.

Homoscedasticity: Error terms have constant variance which indicates that the assumptions of homoscedasticity hold.

Autocorrelation: The error terms should be independent. There is no relation between successive error terms. The Durbin Watson (DW) statistic was used to test autocorrelation in the residuals from a statistical regression analysis. The Durbin-Watson statistic is always having a value between 0 and 4. Values from 0 to less than 2 indicate positive autocorrelation and values from 2 to 4 indicate negative autocorrelation.

Multicollinearity: Co-linearity, or multicollinearity, is the existence of near-linear relationships among the set of independent variables. The presence of multicollinearity was tested by the variance inflation factor, given by the formula:

$$\mathrm{VIF} = \frac{1}{1 - R_i^2} \tag{3}$$

Where R_i^2 is coefficient of determination obtained from X_i on the other explanatory variables. If the value of VIF less than 10 (tolerance greater than 0.1), then there is no multicollinearity in the data.

Result and Discussion

Characteristics of Socio-Economic Variables

As the results shown in Table 2, the average age of the sample respondents was 41 years with minimum age 20 years and maximum age 80 years. Similarly, the average family size of the sample households was 5, with 1 and 9 as minimum and maximum size, respectively. The average education that the farmers attended was grade 2 (Table 2). The results showed that average non-farm income of the surveyed households was USD 29.39 when the average economically active members in family were 3 members. Survey results also revealed that the average cultivated land of the households was 0.41 hectare. The average chemical fertilizers applied by the surveyed farmers was 211.19 kg, whereas the average organic manure applied by respondents was 492 kg. The mean distance between the farmer's home and the market in hours was 6.88 hours. Furthermore, the average distance between the home of household and the DA's office in hours for surveyed households was 1.62 hours (Table 2).

Table 2: Descriptive statistics for continuous variables

Variables	*Mean*	*Std. Deviation*	*Minimum*	*Maximum*
AGEH	41.59	11.58	20	80
FSH	5.82	1.66	1	9
EDLH	2.44	3.59	0	12
NFI	29.39	107.156	0	807.508
CAL	0.41	0.53	0.06	5
DTM	6.88	27.27	30	120
DTDA	1.62	13.82	2	60
EAM	3	1.01	1	6
AFU	211.19	164.08	0.00	800
AOFU	492	511	0.00	2000

AGEH = Age of Household, FSH = Family size of household, EDLH = Educational level of household, NFI = Non-farm income, CAL = Cultivated area of land, DTM = Distance to the market, DTDA = Distance to Developmental Agency's office, EAM = Economically active members, AFU = Quantity of fertilizer used, and AOFU = Quantity of organic fertilizer used.

The results in (Table 3) showed that 80% of surveyed respondents have access to market information. The access to market facilitates productivity and effectiveness of agricultural marketing amenities. 34.5% of surveyed households participated in social organizations too.

Table 3: Descriptive statistics for dummy variables

Variables	*Sample Households*	*Number*	*Percent (%)*
AMI	Yes	160	80.0
	No	40	20.0
SSH	Participated	69	34.5
	Not	131	65.5

AMI = Access to market information, SSH = Social status of household

Multiple Linear Regression Analysis for Maize Production

In order to know the determining factors that influence the production of maize crop, multiple linear regression model was employed. Firstly, the overall model adequacy was checked, then the model coefficients were analyzed. The model summary output indicated the strength of the association of the explanatory variables and the response variable. According to the model adequacy as shown in Table 4, the value of the correlation coefficient (R) was 0.85, which indicated that there was a strong association between

the maize production and other explanatory variables. The value of the coefficient of determination (R^2) was 72.25%, which indicated that 72.25% of the variation in the maize production was explained by other explanatory variables. Therefore, the model was adequate. This finding is consistent with Bukul (2018) who investigated factors affecting smallholder farmers' potato production. He found that the coefficient of determination was used to plaid the goodness of fit for the regression model. This finding is also in line with the finding of Bezawit (2011) and Mersha, Demek and Birhanu (2017).

Table 4: Model adequacy checking summary

Model	*R*	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*	*Durbin-Watson*
1	0.850[a]	0.7225	0.689	14.67493	2.034

Hypothesis Testing for the Model

Generally, the hypothesis testing is a technique used to test the joint effect of the explanatory variables on the response variable. ANOVA is a useful test for the ability of the model to explain any variation in the dependent variable, but it does not directly address the strength of the association between the variables. As indicated in Table 5, the overall model estimation is statistically significant, which means at least one of the parameters or coefficients of explanatory variables is different from zero.

Table 5: Overall Result of Analysis of Variance (ANOVA)

Model		*Sum of Squares*	*Df*	*Mean Square*	*F*	*Sig.*
1	Regression	82569.277	12	6880.773	32.478	0.004[b]
	Residual	39616.911	187	211.855		
	Total	41860.189	199			

As displayed in Table 6, non-farm income of the households, the cultivated area of land, distance to Developmental Agent's (DA's) office, economically active members, quantity of fertilizer used, quantity of organic manure applied and social status of household head in the community are statistically significant at 5% level of significance. This indicates that those variables are considered as important determinants that affect the maize production of farmers. The remaining explanatory variables - age of household head, family size of households, educational level of households, distance to nearest market and access of market information - were found to be not statistically significant at 5% level of significance.

Non-farm income of households has a positive and significant impact on the maize production as shown in Table 6. This is because the farmers spent additional income to buy inputs like improved seeds, chemical fertilizers and farm equipment for maize production and thus yielded more maize production compared to those who had not additional income. This finding is consistent with Bukul (2018). His finding revealed that involvement in off-farm activity had a positive impact on the potato production. Similarly, the cultivated area of land had a positive and significant effects on the farmers' production of maize in the study area. By increasing cultivation area, yields of maize production increased. This result is confirmed with the finding of Ahmed (2016). DA's office distance has a negative impact on the maize production and is significant at a 5% significance level (Table 6). The accessibility to improved agricultural information aids farmers to produce high crop diversity and to get higher production of maize crops. Similar result is reported by other researchers like Yuya and Daba (2018).

The result in Table 6 showed that the numbers of economically active members in a family have positive and significant influence on the maize production of smallholder farmers. This result matches with the findings of Yuya and Daba (2018). Moreover, quantity of fertilizer used has a positive impact on the yield of maize crop productivity. As the quantity of fertilizer increased by one kg, the quantity of maize production of smallholder farmers increased by 1.02 quintal, when other explanatory variables were kept unchanged. This result was consistent with the finding of Rao and Ketema (2016). The quantity of organic manure also has positive effect on the maize production of smallholder farmers and is statistically significant

at 5% probability level. The result indicated that as the quantity of organic manure increased by one kg, the quantity of maize production of farmers has increased by 1.30 quintal, while keeping other explanatory variables constant. This result was consistent with Eneyew and Bekele (2012). Membership to social group was found to have a negative and significant impact on maize production of households. Thus, a communal wealth that encourages the distributing of knowledge, information, and skill concerning the worth of off- and non-farm events that benefit them to advance their income. This finding was inconsistent with the findings of Eneyew and Bekele (2012).

Table 6: Multiple regression analysis for variables predicting the production of maize crop

Variables	*Coef.*	*Std. Error*	*t-stat*	*Sig.*	*Tolerance*	*VIF*
(Constant)	1.321234	0.225640	5.855	0.838	-	-
AGEH	2.004721	0.296236	6.767	0.622	0.881	1.135
FSH	1.552358	0.382254	4.061	0.648	0.850	1.176
EDLH	2.933278	0.424568	6.908	0.000*	0.929	1.076
NFI	-0.051460	0.426235	-0.120	0.904	0.461	2.169
CAL	1.723407	0.302724	5.693	0.000*	0.942	1.062
DTM	3.852632	0.483389	7.970	0.425	0.439	1.566
DTDA	-4.452140	0.656810	-6.778	0.006*	0.885	1.131
EAM	1.291884	0.256123	5.044	0.008*	0.675	1.481
AFU	1.024562	0.385845	2.655	0.007*	0.568	1.761
AOFU	1.308254	0.267569	4.889	0.001*	0.580	1.725
AMI	-1.702520	0.426765	-3.989	0.717	0.906	1.103
SSH	2.853560	0.428231	6.663	0.000*	0.864	1.157
Number of observations		200				
F(12, 188)		32.478				
Prob>F		0.000				
R-Squared		0.7225				

AGEH = Age of household, FSH = Family size of household, EDLH = Educational level of household, NFI = Non-farm income, CAL = Cultivated area of land, DTM = Distance to the market, DTDA = Distance to Developmental Agency's office, EAM = Economically active members, AFU = Quantity of fertilizer used, AOFU = Quantity of organic fertilizer used, AMI = Access to market information, SSH = Social status of household, and * indicates significance at 5% probability level.

Model adequacy checking

Normality: The result revealed that the error terms were normally distributed approximately with mean zero and constant variance (Figure 1). This indicated that the error terms and explanatory variables were not correlated to each other. This means the models were well defined. The shape of the histogram should approximately follow the shape of the normal curve. Therefore, the assumption of normality was fulfilled. This was in line with the finding of Rao and Ketema (2016).

Homoscedasticity*:* As seen from Figure 2 of the residuals versus the fitted value (the production of maize crop), there was no relationship between the residuals and the fitted value of maize production. This indicated that there was no heteroscedasticity in the data. This means that the error term ε_i's were independently and identically distributed having a normal distribution with mean zero and constant variance σ_ε^2.

Multicollinearity*:* As indicated in Table 6, there was no serious multicollinearity problem among the explanatory variables including the model because all VIF values were less than 10 and all values of tolerances were greater than 0.1.

Autocorrelation*:* As pointed out in Table 4, there was no autocorrelation between the error terms because the Durbin Watson statistic was 4.52, which was outside of the acceptance region (greater than 4).

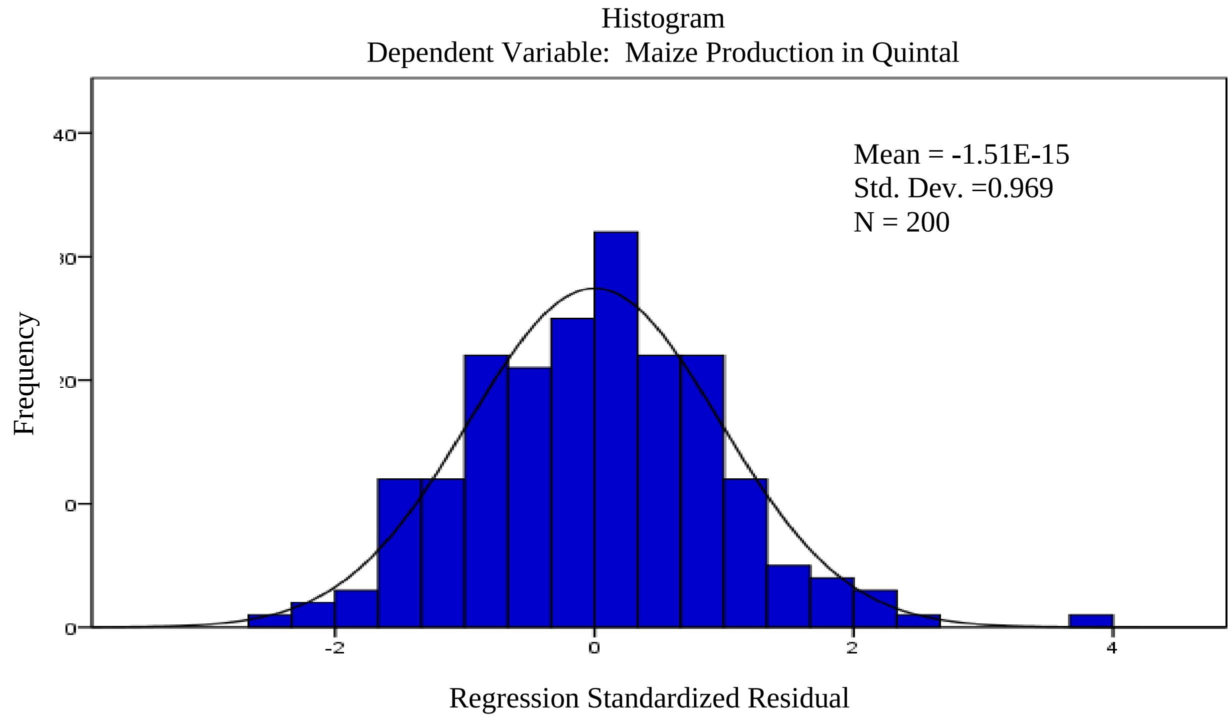

Figure 1. Histogram of residual against frequency of maize production

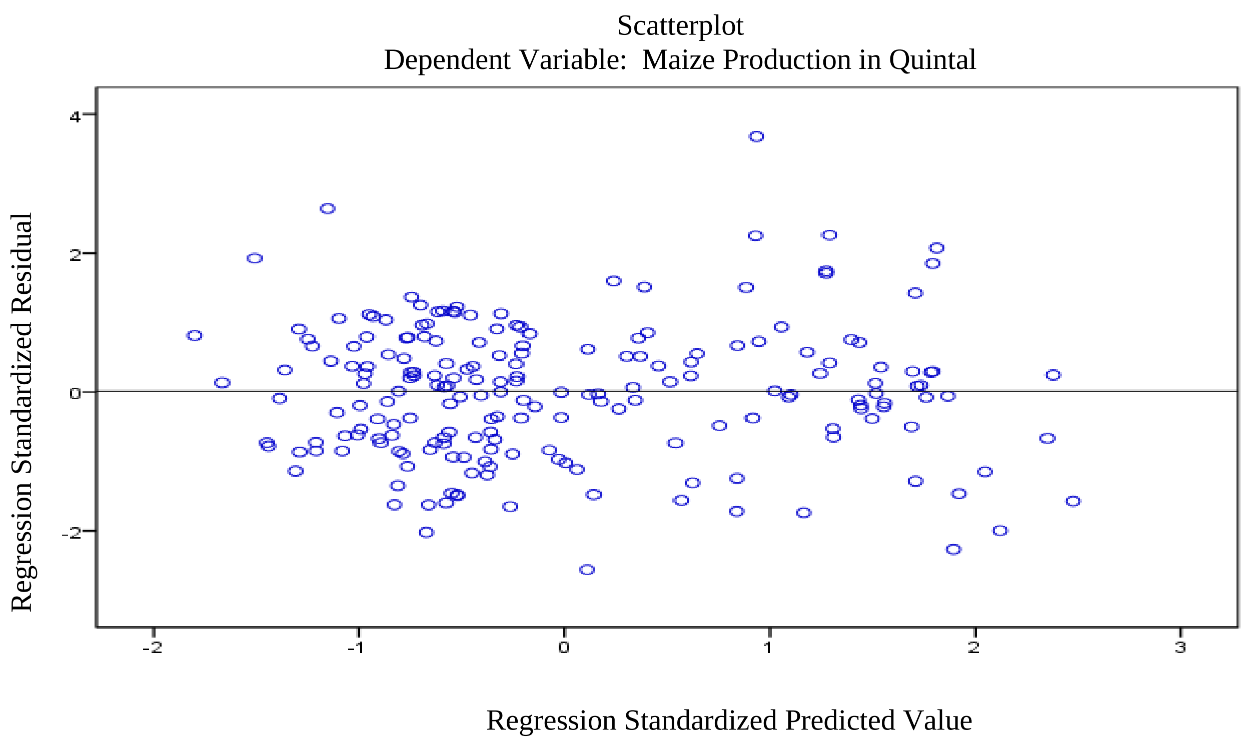

Figure 2. Scattered plot of standardized residual versus standardized predicted value

Conclusion and Recommendations

To increase the income and reduce rural poverty among smallholder farmers, agriculture needs improvement through increasing production and productivity of cereal crops. Therefore, improving the smallholder farmers' maize production is required to improve access to food and sustainable livelihoods. Therefore, this study was carried out to identify the household level determinants of maize production among smallholder farmers in the Meta district, East Hararge zone, Oromia region, Ethiopia. The result of the study showed that non-farm income of the household, the cultivated area of land, distance to DA's office, economically active members in family, quantity of fertilizer used, quantity of organic manure applied, and social status of households were important determinant of maize production among smallholder farmers. The non-farm income and cultivated area of households have positive impact on maize production. The economically active members of households have positive influence on maize production. The quantity of fertilizer used, and organic manure applied have a positive impact on the yield of maize crop productivity.

Consequently, maize productivity of smallholder farmers is fundamental in securing households' food security and reduce poverty, which in turn can ensure the wellbeing of farmer households. Therefore, government and non-government as well as other stakeholders should inspire farmers for up-to-date maize production and supply improved seeds, fertilizers and other improved technologies that support developing their farm households' prosperity.

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Authors' Declarations and Essential Ethical Compliances

Authors' Contributions (in accordance with ICMJE criteria for authorship)

Contribution	Author 1	Author 2
Conceived and designed the research or analysis	Yes	Yes
Collected the data	Yes	Yes
Contributed to data analysis & interpretation	Yes	Yes
Wrote the article/paper	Yes	Yes
Critical revision of the article/paper	Yes	Yes
Editing of the article/paper	Yes	No
Supervision	Yes	No
Project Administration	Yes	No
Funding Acquisition	No	No
Overall Contribution Proportion (%)	70	30

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Research involving human bodies (Helsinki Declaration)
Has this research used human subjects for experimentation? No

Research involving animals (ARRIVE Checklist)
Has this research involved animal subjects for experimentation? No

Research involving Plants
During the research, the authors followed the principles of the Convention on Biological Diversity and the Convention on the Trade in Endangered Species of Wild Fauna and Flora.

Research on Indigenous Peoples and/or Traditional Knowledge
Has this research involved Indigenous Peoples as participants or respondents? No

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